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ZERO REACTION WORKSPACE OF A SPACE MANIPULATOR

Abstract

The minimization of the dynamic disturbances transferred to the base spacecraft by a space manipulator is an important issue in Space Servicing missions because it leads to fuel savings of the Reaction Control System and, therefore, to an increased operating life of the system. Recently, the authors presented an original reaction control method for redundant space manipulators based on Constrained Least Squares, which has several advantages with respect to the previous local optimization methods proposed in the literature, such as a simple mathematical formulation, the possibility to use simple least-squares real-time routines for the solution, and the possibility to take into account the joint limits and the joint velocity and acceleration limits of the manipulator. In this paper the proposed reaction control method is used in order to define and study the workspace in which a zero reaction can be obtained. The Zero Reaction Workspace of a free-floating base manipulator which has a degree of redundancy equal to the number of the reaction components to be controlled has been computed for different arm/base mass ratios, and considering the joint limits of the manipulator or not. In particular, it has been shown that the free-floating base Zero Reaction Workspace is always contained in the fixed-based one, which is obtained considering a very massive spacecraft. Different arm initial configurations, end-effector trajectories and velocity profiles have been tested, leading to the identification of the more important parameters which influence the Zero Reaction Workspace. An important characteristic of the Zero Reaction Workspace is that inside it the proposed local optimal reaction control method has global characteristics and, therefore, a global optimal solution is obtained at the computational cost of a local optimal one. Finally, the experimental validation of the Zero Reaction Workspace, considering the joint limits or not, has been carried out for a planar three degrees of freedom manipulator fixed on ground by means of a dynamometer in order to measure the reactions and suspended by means of air bearings in order to perform the tests in simulated microgravity.